




# Roar of the Thunder

While the JF-17 has come of age in the combat theatre, it has yet to record any major successes in the export market. **Sqn Ldr (Ret'd) Fahad Masood (MRAeS)** charts the development of the light fighter and explores how the new Block III standard could help to expand the aircraft's customer base in the coming years





**A JF-17 Block I (serial 13-147) from No 2 (Multi-Role) Squadron 'Minhasians' departs PAF Base Samungli, Pakistan, to take part in a dissimilar air combat training exercise in 2021**  
All images: SalmanFalconsPK

**'S**cramble! Angels 1-4-0! Initial Vector 1-5-0!' The command was still ringing in the pilot's mind as he strapped into his Martin-Baker PK16LE ejection seat. He glanced through his custom-fitted helmet-mounted display (HMD) to confirm the removal of seeker covers of all the missiles on board his Block III JF-17. Two high-off boresight (HOBS) PL-10E short-range infrared (IR)-homing air-to-air missiles (AAMs) on the side rails. Check. Four PL-15 active radar-guided long-range AAMs on multiple missile launchers (MMLs). Check.

After making the aircraft 'battle-ready' following a brisk engine start and taxiing out, the pilot co-ordinated with air traffic control and his radar. Alongside his wingman, they lined up on the runway, engaged afterburners and – with 19,000lbf behind them – were boring holes through the sky in no time.

This scenario is set to be acted out in a few months time, when Block 3 JF-17s, with new Chinese missiles, join the Pakistan Air Force's (PAF's) ranks.

The Pakistan Aeronautical Complex-Chengdu Aircraft Corporation (PAC-CAC) JF-17 has come of age. From its meagre beginnings as the Sabre II to Super-7, then FC-1 and eventually JF-17, the programme has evolved from being a J-7/F-7 variant to a multi-role fighter that held its own during Operation Swift Retort – a series of airstrikes at locations in the Indian-administered Jammu and Kashmir regions on February 27, 2019.

From being a mere replacement for a variety of aircraft types in PAF service, the jet has become a link-sensor-fused terminal for a network-centric air arm.

### **New kid on the 'Blocks'**

It is safe to say that the Thunder package is the latest economical and hard-hitting solution for developing countries facing the challenge of replacing ageing fleets of air defence platforms. Designed as a three-and-a-half to fourth-generation fighter aircraft, the JF-17 is a bargain in the present expense-driven world of aviation.

The platform is open-source and configurable, like android-based information and communications devices, instead of being closed-source, like Apple-based

products. This directly points to it being a 'no strings attached' platform, where the operator has complete control of how to organise the weapon system and expose its maximum potential. Based on modular maintenance principles, this becomes a cinch at any level.

The ease of flying the Thunder is demonstrated by the fact a two-seat variant was not felt necessary by pilots and supervisors until late into the development of the Block II standard. A high-fidelity simulator was good enough to get less experienced fighter pilots 'hands on' and then on to the real thing. However, flying the jet is one thing, employing it in a variety of combat roles is another.

### **Let the games begin**

Started as a \$500m joint venture between Pakistan and China in the late 1980s, under the Sabre II moniker, the JF-17 was developed with export potential to various developing nations in mind.

Then came the US's Pressler Amendment in 1985 – which banned most economic and military assistance to Pakistan, unless it certified on an annual basis that it did not possess an explosive nuclear device, and subsequently forced the PAF to drop out of the Sabre II programme. China was dealt a similar card by the US, due to its stern handling of the Tiananmen Square protests in 1989.

In 1991, the Fighter China project officially began and there has been no stopping its progress ever since. After Pakistan and China signed the Memorandum of Understanding in 1995, Mikoyan joined in to provide design support. In February 1998, a Letter of Intent was inked regarding airframe support and the provision of RD-93 afterburning turbofan engines from Russia-based Klimov.

By the end of the 1990s, the Sabre II had been rebranded as the Chengdu FC-1/Super-7. In June 1999, an official joint production/development contract was signed between China and Pakistan. The project paced rather well, thanks to the extensive use of computational fluid dynamics and data-driven, computer-based simulations.

The first prototype (PT-01) entered production in September 2002 and was powered by the first

# Thunder





**Pulling Gs:** This PAF-operated JF-17 Block II (serial 16-233) – assigned to No 14 (Multi-Role) Squadron ‘Tailchoppers’ – banks hard while conducting a display during the Pakistan Day Parade on March 23, 2021

A quartet of JF-17s from the PAF's No 14 (Multi-Role) Squadron ‘Tail Choppers’ at PAF Base Minhas, near Kamra in northern Pakistan, conduct a ‘thunderous’ flypast over Islamabad during the Pakistan Day Parade on March 23, 2021



**Flying the flag:** This special-schemed JF-17 Block I (serial 09-111), proudly painted in the colours of the Pakistani national flag, gets airborne from PAF Base Peshawar in northern Pakistan. This specific aircraft is assigned to No 26 (Multi-Role) Squadron ‘Black Spiders’, which is a component of No 36 Tactical Attack Wing

batch of Klimov RD-93s. After a gruelling decade of development work, PT-01 was rolled out at the Chengdu Flight Test Centre in May 2003, before going on to complete its maiden flight in August that year. In April 2004, PAF test pilots completed their first flights in PT-01 and PT-03.

Immediately afterwards, intake restructuring was conducted, to cater for excessive black smoke, along with the installation of a diverterless supersonic inlet and leading-edge extension, to fix early controllability issues. In April 2006, PT-04 took to the skies after being pre-fitted with a fourth-gen sensor-fused avionics suite and digital electronic engine control (DEEC) functions for the RD-93, among other things. PT-06 made its first flight in September 2006, equipped with the PK16LE ejection seat.

The first consignment of two small-batch production JF-17s arrived in Pakistan in March 2007, to participate in a public aerial demonstration during the Pakistan Day parade. In November that year, the LETRI SD-10 active radar-guided beyond-visual-range AAM (BVRAAM) was put on the rails for the first time.

In June 2009, the JF-17 assembly line in Pakistan officially launched operations. The Block II variant of the multi-role fighter entered production at PAC's Kamra facility in December 2013, bringing with it new air-to-air refuelling; electronic warfare (EW); enhanced avionics; load-carrying capacity and datalink capabilities. A two-seat Block II-configured





# Myanmar & Nigeria

The first export order for the Thunder came in July 2015, when Myanmar procured 16 examples from Pakistan and China, along with 16 spare RD-93 engines from Russia in a separate deal that was signed that same year.

The initial batch of JF-17Ms were delivered to the Myanmar Air Force in 2018, with the final aircraft arriving in 2019. To date, the nation has received seven JF-17M Block IIs, five JF-17As and two JF-17Bs.

With regards to Nigeria's procurement of the platform, negotiations effectively started during the International Defense Exhibition and Seminar in Karachi, Pakistan, in December 2014. At the time, the African nation was reportedly interested in acquiring between 25 and 40 JF-17s. An initial commitment to the fighter had been shown by then-Nigerian Air Force (NAF) chief, Air Marshal Adesola Nunayon Amosu, during a visit to Pakistan in October 2014.

Nigeria became the type's second export customer in 2016, when it placed an order for three aircraft. A subsequent \$184.3m deal was approved by Pakistan in 2018 for the delivery of a further three examples.

The NAF's first JF-17A Block IIs were rolled out from PAC's Kamra facility on December 30, 2020. They were delivered to Makurdi Air Base in Nigeria via a PAF-operated Ilyushin Il-78MP heavy-lift strategic transport in March 2021. On May 21, the NAF formally inducted the type into operational service.

Reports from Nigerian media outlets state that the NAF is extremely pleased with the JF-17, and it is expected that a further 35-40 examples will be ordered.



Equipped with live 500lb Mk.82 general-purpose bombs, this JF-17 Block I (serial 12-142) from No 2 (Multi-Role) Squadron 'Minhasians' taxis at PAF Base Masroor, before a bombing mission at the Sonmiani Firing Range in 2021

JF-17 variant was also developed for training and stand-off weapon (SOW) employment purposes.

However, the new Block III version of the JF-17 will feature an improved flight management system; active electronically scanned array (AESA) radar; a HMD; a chin rack hardpoint and possibly extra BVR carriage capacities on the centreline station.

## Block III

The first JF-17 Block III prototype (serial 3000) took to the skies for its maiden flight over Chengdu in December 2019. It has been a while since this milestone, and serial production has yet to begin. A lot has been rumoured regarding its featured capabilities. To date, the platform is known to have the following competencies:

- **Radar:** With all Western options having been disregarded, the X-band KLJ-7A liquid-cooled, airborne AESA Fire Control Radar (FCR) became the system of choice for the Block III JF-17. Reports state that while targeting

an adversary fighter with a radar cross-section (RCS) of 53ft², the detection range in air-to-air mode was 65% higher than that of the prototype, with a range of more than 81nm. Multi-target tracking capabilities were further enhanced, giving the platform an ability to simultaneously track targets of 'nth' number and attack four of them at the same time.

As is already known, the modes of any AESA radar vary in operation from the predecessor Pulse-Doppler system in all roles. Among many others, one such

feature is the 'interleaf' mode – where both airborne and surface targets are tracked at the same time, due to its inherent enhanced architecture. It is also known that the radar range exceeds any present or future BVRAAM to be inducted in the programme.

- **Head-up display (HUD):**

Upgraded to a new frameless, wide-angle diffractive type – which is significantly larger in size than the original – the Block III's holographic Smart-HUD will likely replace the system used by the Chengdu J-10C and J-20A. The Chengfei Institute is producing the new HUD for all three platforms.

- **HMD:** The HMD used for the Block III JF-17 is lighter than the one in use for the PAF's F-16 Fighting Falcon fleet. Custom designed and manufactured for each specific pilot, the system is integrated with the PL-10E missile for HOBS shots.

- **Air-to-air weapons:** The Block III upgrade brings with it two major weapons developments in the form of the PL-10E, with



A JF-17 from No 28 (Multi-Role) Squadron 'Phoenix' rests on the ground at PAF Base Samungli following a training flight in 2021. Note the empty dual ejector racks under each wing





Ground crew conduct a ground run of JF-17 Block II (serial 16-232) to pick up data via a laptop, in a bid to diagnose possible errors with the aircraft



Above: JF-17B Block II (tail number 2P-79B) is seen on glide slope as it conducts an instrument landing system approach for landing following a test flight. Note the aircraft is still wearing its primer and has yet to receive its operational camouflage

Below: This Block III aircraft (tail number 3P03) seen on the PAC Kamra production will be one of the first examples of the new standard to be rolled out. Note that the Block III version features a larger nose cone to accommodate the new KLJ-7A AESA radar and chin rack, which will be located under the intake on the front-right fuselage section



associated HMD for IR imaging guidance HOBS employment, and the PL-15 'Longer Stick' BVRAAM.

The PL-10E, which is a fifth-gen AAM with a larger diameter solid rocket motor, has strong detection capabilities, longer range and excellent manoeuvrability for 90° aspect shots. The missile uses both aerodynamic and thrust-vector control, and is fitted with a multi-element IR seeker, capable of +/- 90° off boresight angles.

Its missile seeker can be slaved to an HMD, enabling the pilot to track a target beyond the aircraft's radar scan envelope, using the munition's HOBS capability, better known as 'look and shoot'. The central portion of the missile has long, thin strakes, which help maintain the weapon's manoeuvrability in the terminal homing stage of flight, after the rocket motor stops firing.

The PL-15 is an active radar-guided BVRAAM with a standalone AESA radar. Its official range exceeds 81nm and its dual-thrust rocket motor enables it to reach speeds of up to Mach 4. With its longer radar detection range and increased anti-jamming capabilities, the PL-15 effectively increases the JF-17 Thunder's anti-access/area denial abilities by targeting high-value assets at greater ranges.

• **Airframe structure:** The Block I and II JF-17s suffered from structural strength issues, resulting in the platform's having limited

stores and load-management capabilities. However, the increased use of composite materials (especially in the wing root and on both upper/lower surfaces) enables the Block III to carry a wider variety and number of weapons.

• **Weapon carriage:** With its aforementioned reinforced structure, in the air-to-air category, two PL-15 or SD-10 AAMs can be railed on each MML – incorporated on outboard underwing stations. Current plans will see an additional missile carried on the centreline station, meaning the Thunder can carry up to five BVRAAMs. This brings the stores management system to an increased number of ten items, with PL-10Es or PL-5Es on the wingtip stations.

As far as Stand Off Weapons (SOW) go, the REK (Range Extension Kit) Mk 80-series Takbir general-purpose bombs have been the munition of choice for the JF-17. However, the Block III has recently been trialling the H-2/4 SOW precision-guided glide bomb and Hatf-VIII (Ra'ad) air-launched cruise missile. Despite being less talked about, the CM-400AKG supersonic cruise missile remains a potent weapon against enhanced adversary air defence systems. The upgraded C-802A subsonic, sea-skimming anti-ship missiles – featuring waypoint planning and on-off-on radar operation with multiple target selection options – are carried as well.



• **Network-centricity:** The JF-17 is fitted with the homegrown Link-17 datalink – a system that will be further matured with the Block III upgrades. This will provide it with a cross-platform capability, enabling it to share information with all air, land and naval assets, to ensure enhanced situational awareness (SA) and battlespace management.

• **Data fusion:** Intra-system data sharing and the interoperability of various systems has been a hallmark of the programme since the start. Growing in maturity through the Block I and Block II models, data fusion aims to improve decision-making via enhanced tactical SA. The use of data-fused Smart HUD and HMD – along with onboard avionics – is a prime enabler to Thunder crews, and the Block III standard aircraft will make the pilot more aware and competent in that domain.

• **Engines:** Engineers have been looking for alternatives to the RD-93 when it comes to powering the JF-17. A couple of solutions may have been found in China with the Shenyang WS-10 and Guizhou WS-13 afterburning turbofan engines – both are maturing quickly and verifying their airworthiness.

While there are reports of WS-10s currently powering the J-10C, the JF-17 Block III programme managers are deeply interested in the upgraded, DEEC-enabled RD-93MA – which

provides more than 20,000lbf (wet) – probably because of the already established supply chain. In parallel, the fielding of both engine types would give the Block III examples interchangeability and wider room to manoeuvre on negotiation tables.

• **Live virtual construct:** With economic constraints playing a major role in determining air operations training, the ability to generate multiple adversaries in the artificial intelligence (AI)-strong Block III cockpit enables both mock BVR and WVR air-to-air combat. First seen in the J-10C as a single adversary with a rudimentary left-right turn capability, it has been matured to empower a formation getting airborne, with enemies in the air, in a virtual domain on a horizontal situation display or radar.

• **Cockpit voice recognition:** With the presence of hands on throttle-and-stick (HOTAS) in a data-fused cockpit, this technology has valuable scope, such as changing communication channels during air combat. Its value can be judged by the fact the F-35 Lightning II is sustaining this technology in an NCO environment. The only limitation is that a voice file must be 'trained' and generated by the pilot before being utilised effectively.

• **Chin rack:** The Block III features an additional hardpoint under the front-right section of the fuselage,

to incorporate the already in-use Aselsan Aselpod advanced targeting pod or any jamming pod that can further enhance the Thunder's EW operations. This hardpoint adds value by vacating the centreline for additional weapons or fuel tanks.

• **EW:** While the Panjnad EW suite is already being incorporated on the Block IIs, the system will be retained by the Block III, due to its results in integration, usability and efficacy in a wide area of the electromagnetic spectrum. Improved data fusion will further enhance its competency.

## Ongoing challenges

While the Block III will provide a variety of new capabilities and systems for the Thunder, it has not been without its challenges. The project is still looking for a suitable infrared search-and-track (IRST) system, because it is not built in to the airframe.

Some potential JF-17 operators want it to be integrated into the airframe and not mounted on an external station, as the Thunder's heat signature hinders its performance. This will not only bolster the targeting capability of the Thunder, but will also allow the IRST to dispense passive detection capabilities to the pilot with PL-10Es. The centreline station will probably be equipped with this system, but an official decision has yet to be made.

# Future exports

The majority of potential Thunder operators are waiting for the Block III model to be completed, assessed and declared airworthy before moving negotiations forward.

In late 2021, a possible deal with Argentina surfaced, after the nation's government requested a budget allocation of \$664m to purchase 12 JF-17 Block IIIs. The Thunder is a candidate to replace the Bolivian Air Force's now-retired Lockheed T-33 Shooting Star fleet.

A new export order from Iraq is also on the cards. The Iraqi Air Force (IqAF) is looking to buy a dozen JF-17 Block IIIs, for which high-level negotiations took place between Pakistan and Iraq last year. These concluded with the recent visit of an Iraqi defence delegation.

Azerbaijan has engaged in JF-17 purchase negotiations since January 2008, with the latest talks taking place during a military co-operation moot with Pakistan in December 2019, where interest in the type was again expressed. Morocco has shown interest in the platform, but is unlikely to make any purchases. The Qatar Emiri Air Force has shown considerable interest in the Block III, but with 96 Dassault Rafales, Boeing F-15QAs and Eurofighters all being purchased in recent years, it's unclear how the JF-17 would fit in.

Other countries that could be identified as potential customers of the new two-seat JF-17B and the promising Block III model include Egypt, Iran and Iraq.



A JF-17 Block III (tail number 3P04) is manufactured at PAC's production facility in Kamra. It looks like the KLJ-7A AESA radar will be an air-cooled system



**With the up-and-coming Block III, there will be greater avenues opening up for potential export**



More than 100 JF-17 Block I/II are in service with the PAF. An additional 25 two-seat JF-17Bs are also operational with the air arm. In total, four aircraft – three single-seaters and one two-seater – have been lost since the type entered Pakistani service in 2010



**Above:** The final touches are applied in the production of this two-seat JF-17B Block II (tail number 2P-80B) at PAC's Kamra facility

**Below:** A new-build two-seat JF-17B Block II (serial 20-626) awaits roll out after receiving its operational PAF colours at PAC's Kamra facility



By the end of 2021, it was expected – by the pace of work and intent of the PAF – ten Block III JF-17s would be airworthy, but the onset of the 'Omicron' variant of COVID-19 and other externalities delayed the delivery of these jets.

The first production Block III completed its first taxi during a ceremony at PAC Kamra on January 1, 2022. In total, eight Block IIIs have so far been delivered to Pakistan's Flight Test Centre to continue testing (starting with high-speed taxi trials) before being officially delivered to frontline PAF units.

## Predicting Thunder

It is reasonably safe to say (with a bit of crystal gazing and considering the mouldability of the JF-17) that a probable Block IV-configured Thunder could have the following capabilities:

- **Manned-unmanned teaming (MUM-T):** Future JF-17s will function as a component of a MUM-T formation with combat or intelligence, surveillance and reconnaissance drones, known as 'remote carriers' or 'loyal wingmen'. This concept is already being developed under a

multi-party programme between Pakistan, China and Turkey. Air arms of the future will be able to deploy these 'loyal wingman' in high-threat environments, to neutralise hostiles while keeping manned fighters at a safe stand-off distance.

- **Combat Cloud:** All the aircraft's nodes will be connected via an AI-powered Combat Cloud that will have multiple firewalled information security frameworks in place to protect it.

- **Low observability:** While 'stealth-by-design' changes are reasonably less practical going forward, 'stealth-by-material' characteristics – such as radar-absorbing material or radar-absorbing paint – will be introduced to mitigate the aircraft's RCS to a minimum possible for deep interdiction ingress and surprise elements.

- **Eye-tracking technology:** Future JF-17 standards will exploit this technology, enabling engineers to remove the increasingly cluttered physical elements of the instrument panel and replace it with a 'wearable cockpit' – a helmet with a virtual reality (VR) display.

The VR helmet includes eye-tracking technology that will



enable pilots to look at something on the virtual display, highlight it, and make a hands-free gesture, such as blinking, to 'press a button'. It will enhance the effectiveness of warning signals, predict the pilot's next move based on where they are looking and suggest the next task, to reduce pilot workload.

## Absent exports

There are multifold reasons as to why the JF-17 hasn't achieved the export success that was targeted during the platform's development.

### • No two-seat variant available:

While possible export customers flight tested the Thunder, they did not seem convinced that the PAF was successfully sending new pilots 'solo' after only conducting a training syllabus on a high-fidelity simulator and a high-speed taxi test.

The requirement for a two-seat 'B' model was passed from programme managers to engineers after rigorous computational fluid dynamics calculations and wind-tunnel tests on a corresponding Reynolds number scaled jet were completed.

Serial production took place in China and Pakistan from 2018-20 – 26 aircraft were built.

Pakistan is using the two-seat JF-17B not only to train future Thunder pilots, but also as a lead-in fighter trainer. In the future, this variant will be used in conducting a reconnaissance role and will be able to carry the Hatf-VIII and H-2/4 long-range AAMs. The Block II-standard

JF-17Bs will also be retrofitted with the KLJ-7A AESA radar.

• **AESA radar:** The JF-17 is a continuously evolving platform. However, nothing materialises without taking requisite measures and managing risks. The same goes for the onboard avionics, namely the KLJ-7 multi-mode, Pulse-Doppler FCR employed by the Block I and II aircraft.

The majority of countries seeking to acquire new fighter platforms to replace ageing fleets are also looking for a sustainable solution that will last a few decades, if not longer.

Hence they did not opt for earlier versions of the JF-17 but have been looking at the fourth-gen Block III variant as a more desirable option.

With AESA radar technology, radio waves can be sent out at different frequencies in multiple directions simultaneously. While passive electronically scanned

array radars may be able to scan larger areas faster, AESA systems scan more precisely. It also brings back more valuable information to those using it, by scanning at different frequencies.

• **'Old friends':** Allies of the past, with a long-standing and overdue financial ledger, present a major hurdle for developing countries looking for a no-strings-attached, configurable fighter platform, such as the JF-17.

Western bloc nations and large countries have long enticed possible customers through economic or political enticements.

One example of such a fallout was the now-failed JF-17 deal with Sri Lanka in June 2015. The Indian establishment sent a very loud and clear message, stating that it would cut its \$400m financial assistance to its neighbour if the deal went

ahead. Sri Lanka found it more in its national interest to adhere to this 'request' and ceased negotiating the JF-17 acquisition.

## Storm's brewing

The JF-17 programme has come a long way in a relatively short amount of time, but as the saying goes: 'Never judge anyone by looking at where he is coming from but where he is headed'.

The efforts put in by generations of Chinese and Pakistani aviators – from the late 1980s to the present – is a direct indicator of the intent behind the programme and its heading, with adequate risk management at all tiers.

The JF-17 is not only here to stay but with the up-and-coming Block III, there will be greater avenues opening up for potential export. However, it remains to be seen which countries will be willing to change from Western to Eastern-made products. **AFM**

**JF-17 Block I (serial 13-143) gets airborne from PAF Base Peshawar for a local sortie**



**This JF-17 Block I (serial 10-128) from No 28 (Multi-Role) Squadron 'Phoenix' basks in the sun at PAF Base Samungli after completing an air-to-ground mission in 2021. Note the aircraft is still equipped with its dual ejector racks as it is prepared for a second sortie**